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Effect of aqueous extracts of allelopathic crops on germination and growth of *Parthenium hysterophorus* L.

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Abstract

Herbicidal effects of aqueous root and shoot extracts of three allelopathic crops, viz. sunflower (*Helianthus annuus* L.), sorghum (*Sorghum bicolor* L.) and rice (*Oryza sativa* L.) were evaluated against germination and growth of the noxious alien weed *Parthenium hysterophorus* L. The study, carried out in petri dishes using 5, 10, 15, 20 and 25% (w/v) aqueous root and shoot extracts of fresh plant materials of the test crops, indicated insignificant effects on shoot length and seedling biomass while germination and root length were significantly reduced by extracts of all the test crops. In a foliar spray bioassay, aqueous shoot extracts of 50 and 100% w/v (on a fresh weight basis) of sunflower and sorghum were applied to 10 day old *Parthenium* plants. The root biomass of *Parthenium* plants was significantly suppressed by 50 and 100% extracts of both the test allelopathic extracts. Both concentrations of sorghum extracts significantly reduced shoot biomass, but sunflower extract was effective only at the lower concentration.

1. Introduction

Parthenium hysterophorus L., a native subtropical species of North and South America, is spreading rapidly in many parts of the world. In Pakistan, especially in rainfed areas of the northern Punjab, it occurs widely along the roadsides, on wastelands and sometimes invades field crops (Javaid and Anjum, 2005). The widespread occurrence of this weed may be attributed to its aggressive behaviour, very high seed production potential and suppressive effects on neighbouring plants through allelopathic interactions (Evans, 1997).

During the past few decades much research had been carried out to explore the allelopathic potential of crops and other plants to control weeds. For example, Dzyubenko and Petrenko (1971) found that root secretions of corn (*Zea mays* L.) inhibited the growth of *Chenopodium album* L., whilst Cheema et al. (1988) demonstrated that aqueous extracts of wheat straw significantly inhibited the germination and growth of field bindweed (*Convolvulus arvensis* L.) and crowfoot grass (*Dactyloctenium aegyptium* L.). Abdul-Rehman and Habib (1989) found that decomposing crop residues of alfalfa (*Medicago sativa* L.) reduced the germination of blady grass [*Imperata cylindrica* (L) Beauv.] by 52%. Recently Ko et al. (2005) have reported the inhibitory effects of husk extracts of seven rice varieties on growth of barnyard grass [*Echinochloa crusgalli* (L.) Beauv.]. Similar adverse effects of water extracts of different *Brassica* spp. on germination and growth of cutleaf ground-cherry weed (*Physalis angulata* L.) have been reported by Uremis et al. (2005). Recently various studies to evaluate the herbicidal potential of allelopathic grasses (Anjum et al., 2005; Javaid et al., 2005) and trees (Shafique et al., 2005) against *Parthenium*, carried out by our research group, have provided very encouraging results. The present study was designed to evaluate the herbicidal effects of three allelopathic crops viz. sorghum, sunflower and rice, on the germination and growth of *Parthenium*.

2. Materials and methods

2.1. Germination and early seedling growth bioassays

Three field crops namely sunflower, sorghum and rice were chosen for the experimental work. The decision to choose these

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Table 1
Effects of aqueous root and shoot extract of three allelopathic crops on germination and early seedling growth of *Parthenium hysterophorus*

Test species	Treat	Shoot extract				Root extract			
		Germ. (%)	Shoot length (mm)	Root Length (mm)	Fresh Wt. (mg)	Germ. (%)	Shoot length (mm)	Root length (mm)	Fresh wt. (mg)
Control	0%	100 a	6.5 a–e	4.9 a	1.7 c–g	100 a	6.5 ab	4.9 a	1.7 a–e
Sorghum	5%	81 bc	4.8 e	4.0 ab	1.2 g	100 a	4.9 bc	4.1 a–c	1.3 de
	10%	75 bc	4.6 e	3.1 b–d	1.5 e–g	87 ab	5.3 bc	3.9 a–c	1.4 c–e
	15%	69 cd	5.1 de	2.7 c–e	1.4 fg	87 ab	4.1 c	2.9 b–d	1.3 de
	20%	75 bc	4.8 e	2.5 c–e	1.7 d–g	81 ab	4.6 bc	2.5 cd	1.3 de
	25%	75 bc	4.7 e	3.1 b–d	1.9 b–g	56 c	4.9 bc	4.2 ab	1.03 e
Sunflower	5%	100 a	7.7 a	3.4 bc	2.2 a–f	92 a	8.1 a	2.9 b–d	2.8 ab
	10%	81 bc	7.7 a	3.4 bc	2.5 a–e	87 ab	7.8 a	3.1 b–d	2.7 a–c
	15%	65 cde	7.3 ab	2.8 c–e	2.3 a–f	69 bc	7.7 a	2.6 b–d	2.9 a
	20%	55 de	5.5 c–e	3.2 b–d	2.7 a–c	68 bc	8.3 a	3.2 b–d	2.8 ab
	25%	50 e	5.6 b–e	2.2 de	2.4 a–e	69 bc	7.4 a	3.3 b–d	2.2 a–e
Rice	5%	100 a	6.9 a–d	3.6 bc	2.65 a–d	100 a	4.5 bc	2.2 d	1.9 a–e
	10%	87 ab	6.5 a–e	3.2 b–d	2.73 a–c	81 ab	4.6 bc	1.9 d	1.5 b–e
	15%	90 ab	7.2 a–c	3.0 b–d	2.8 ab	90 ab	4.5 bc	2.5 cd	2.4 a–d
	20%	80 bc	7.6 a	2.5 c–e	3.0 a	87 ab	4.1 c	1.8 d	1.7 a–e
	25%	56 de	5.6 b–e	1.8 e	1.85 b–g	87 ab	8.0 a	2.8 b–d	2.8 ab

Values with different letters in a column show significant differences ($P=0.05$) as determined by Duncan's Multiple Range Test.

particular crops was based on their availability in our vicinity and their well-established allelopathic potential against other plant species (Cheema et al., 1997; Dahiya and Narwal, 2003; Ko et al., 2005).

Plants of test allelopathic crops were uprooted from the fields of Quaid-e-Azam Campus, University of the Punjab Lahore, Pakistan and were taken immediately to the laboratory where they were washed thoroughly with tap water and separated into root and shoot. Fresh materials were blended and soaked in distilled water at 25 g 100 ml^{-1} for 24 h at 25 °C. The solutions were first filtered through a double layer of muslin cloth and then through Whatman No. 1 filter paper. These 25% (w/v) extracts of fresh root and shoot were further diluted to obtain 20, 15, 10 and 5% solutions.

The effects of different concentrations of the aqueous extracts on germination and early seedling growth of *Parthenium* were studied in a laboratory bioassay. For this, 10 seeds of *Parthenium* were placed in a 9-cm Petri dish lined with a Whatman No. 1 filter paper moistened with 3 ml of different concentrations of aqueous extracts. Treatment in a similar manner, but with distilled water, served as the control. For each treatment, three replicates were maintained in a completely randomized design. Plates were incubated in a growth chamber at 25 °C under 10 h light periods daily. After 7 days, seed germination, and seedling root/shoot length and fresh biomass were determined.

2.2. Foliar spray bioassay

Plastic pots of 7-cm diameter and 6-cm depth were filled with sandy loam soil at 130-g soil per pot. Ten-day-old *Parthenium* plants were carefully transplanted to these pots. Aqueous extracts of 100 and 50% (w/v) of fresh sunflower and sorghum shoot materials were prepared as described earlier. These extracts were sprayed on pot grown *Parthenium* plants after 0, 5 and 10 days of

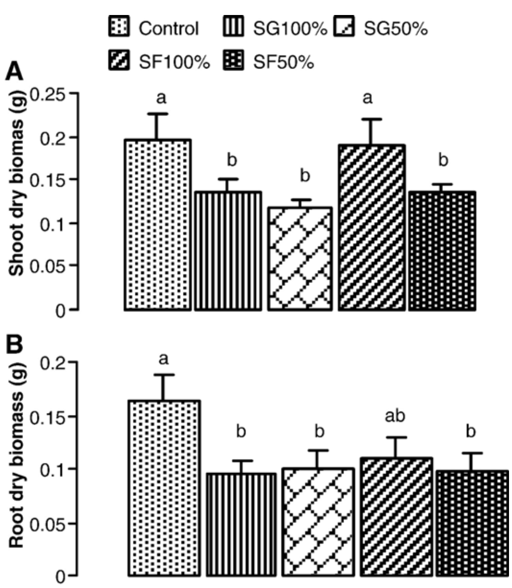

Fig. 1. Effect of foliar spray of sorghum (SG) and sunflower (SF) on root and shoot growth of *P. hysterophorus*. Vertical bars show standard error of mean of three replicates. Values with different letters show significant difference ($P=0.05$) as determined by Duncan's Multiple Range Test.

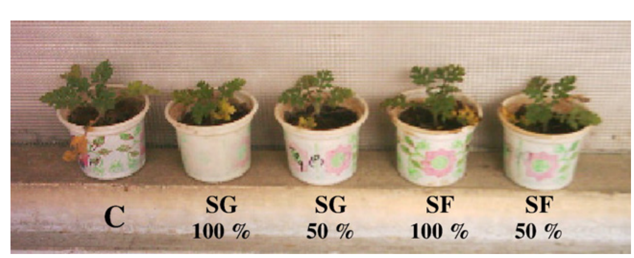

Fig. 2. Effect of foliar sprays of aqueous extracts of sorghum (SG) and sunflower (SF) on growth of *Parthenium*. C = control.

transplantation. Plants in the control treatment were sprayed with distilled water. Plants were harvested after 2 weeks and data regarding root and shoot dry biomass were determined.

2.3. Statistical analysis

All the data were analyzed by one-way ANOVA and the means were separated by Duncan's Multiple Range Test (Steel and Torrie, 1980) at $P = 0.05$.

3. Results and discussion

3.1. Germination and early seedling growth bioassays

Effects of both root and shoot extracts of test allelopathic crop species on shoot length and seedling biomass of *Parthenium* were insignificant. By contrast, germination and root length of *Parthenium* were significantly reduced by aqueous extracts of all the test species. The inhibitory potential of the extracts, however, was found to vary with the specific allelopathic species as well as their individual parts used for extract preparation (Table 1).

Aqueous shoot extracts of sorghum were highly toxic to germinating *Parthenium*. All the applied concentrations of shoot extract significantly suppressed the germination of the test weed. Root extracts were comparatively less toxic, with only the highest concentration of 25% significantly suppressing germination (Table 1). Aqueous extracts of sorghum also exhibited significant phytotoxic activity against root growth of *Parthenium*. Shoot extracts were more effective than root extracts. Earlier, Al-Saadawi et al. (1986) reported that water extracts of different cultivars of sorghum significantly reduced the germination of redroot pigweed (*Amaranthus retroflexus* L.). Similarly, Einhellig and Souza (1992) found that root exudates of sorghum reduced the growth of many test weeds. Cheema (1988) have reported that *S. bicolor* contains nine allelochemicals, viz. benzoic acid, p-hydroxy benzoic acid, vanillic acid, m-coumaric acid, p-coumaric acid, gallic acid, caffeic acid, ferulic acid and chlorogenic acid, which are responsible for its phytotoxic activity against weeds. Sorgoleone is an allelochemical exuded from the roots of sorghum (Netzly and Butler, 1986) that suppresses the growth of weeds (Forney and Foy, 1985).

All applied concentrations of shoot extract of sunflower, except 5%, significantly reduced the germination of *Parthenium*. Root extracts exhibited less toxicity and only concentrations of 15% and above caused significantly adverse effects on germination of the test weed. Root growth of *Parthenium* was significantly suppressed by all the applied concentrations of both root and shoot extracts (Table 1). Aqueous extracts of sunflower are also known to inhibit the germination and growth of other plant species, e.g. *Linum usitatissimum* (Mehboob et al., 2000), and wheat (Ghafar et al., 2000). The heliannuols are a promising group of phenolic allelochemicals isolated from sunflower (Macias et al., 1992).

Rice extracts exhibited least inhibitory activity. Only the higher concentrations of shoot extracts (20 and 25%) significantly inhibited the germination of *Parthenium* seeds, whereas all root extracts were ineffective. The length of *Parthenium* roots was inhibited significantly by all the applied concentrations of both root and shoot extracts (Table 1). Allelochemicals from rice reported so far have, in general, been shown to be phenolic compounds (Rimando et al., 2001). However, Mattice et al. (1998) and Ko et al. (2005) reported that some fatty acids such as linoleic, oleic, searic, 9-octadecenoic and 7-octadecenoic acids from rice showed allelopathic effects on the growth of ducksalad and barnyardgrass.

3.2. Foliar spray bioassay

Foliar sprays with both 50 and 100% sorghum extracts significantly reduced root and shoot biomass of *Parthenium* (Figs. 1A and 2). Similar inhibitory effects of foliar sprays of sorghum extract have also been reported against other weed species. Cheema et al. (1997) reported that two foliar sprays of sorghum extract inhibited weed dry biomass by 15–53% and improved wheat yield by 14%. Similarly Cheema et al. (2000) found that two foliar sprays of sorghum extracts significantly reduced weed density and biomass in cotton.

The root biomass of *Parthenium* plants was significantly suppressed by sprays of both 50 and 100% extracts. However, shoot biomass of *Parthenium* was significantly suppressed only by the 50% shoot extract (Figs. 1B and 2).

The present study concludes that sorghum and sunflower extracts have significant herbicidal effects on the germination and growth of *Parthenium*. Crop residues of these two species could be spread on wastelands, resulting in the leaching of allelochemicals that would reduce the seed germination and consequently the population of *Parthenium*. However, further studies are required to identify and isolate the most effective allelochemicals from these two crops and develop natural-product based herbicides to control one of the world's most aggressive weeds.

References

Abdul-Rehman, A.A., Habib, S.A., 1989. Allelopathic effect of alfalfa (*Medicago sativa*) on bladygrass (*Imperata cylindrica*). Journal of Chemical Ecology 15, 2289–2300.

Al-Saadawi, I.S., Al-Uqali, S.J.K., Al-Hadithy, S.M., 1986. Allelopathic suppression of weed and nitrification by selected cultivars of *Sorghum bicolor*. Journal of Chemical Ecology 12, 209–219.

Anjum, T., Bajwa, R., Javaid, A., 2005. Biological Control of *Parthenium* I: Effect of *Imperata cylindrica* on distribution, germination and seedling growth of *Parthenium hysterophorus* L. International Journal of Agriculture and Biology 7, 448–450.

Cheema, Z.A., 1988. Weed control in wheat through sorghum allelochemicals. PhD Thesis, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan.

Cheema, Z.A., Ahmad, S., Majeed, S., Ahmad, N., 1988. Allelopathic effects of wheat straw on germination and seedling growth of two weed species and cotton. Pakistan Journal of Weed Science Research 1, 118–122.

Cheema, Z.A., Luqman, M., Khalid, A., 1997. Use of allelopathic extracts of sorghum and sunflower herbage for weed control in wheat. Journal of Applied and Pure Sciences 7, 91–93.

Cheema, Z.A., Asim, M., Khaliq, A., 2000. Sorghum allelopathy for weed control in cotton. International Journal of Agriculture and Biology 2, 37–41.

Dahiya, D.S., Narwal, S.S., 2003. Allelopathic plants. 7. Sunflower (*Helianthus annuus* L.). Allelopathy Journal 11, 1–20.

Dzyubenko, N.N., Petrenko, N.I., 1971. On biochemical interaction of plant and weeds. In: Grodzinsky, A.M. (Ed.), Physiological–Biochemical Basis of Plant interactions in Phytocenoses. Naukova Dumka, Kiev, pp. 60–66.

Einhellig, F.A., Souza, I.F., 1992. Phytotoxicity of sorgoleone found in grain sorghum root exudates. Journal of Chemical Ecology 18, 1–9.

Evans, H.C., 1997. *Parthenium hysterophorus*: a review of its weed status and the possibilities for biological control. Biocontrol/News and Information 18, 89–98.

Forney, D.R., Foy, C.I., 1985. Phytotoxicity of products from rhizosphere of sorghum–sudangrass hybrid. Weed Science 33, 597–604.

Ghafar, G., Saleem, B., Qureshi, M.J., 2000. Allelopathic effects of sunflower on germination and seedling growth of wheat. Pakistan Journal of Biological Sciences 3, 1301–1302.

Javaid, A., Anjum, T., 2005. *Parthenium hysterophorus* L. — a noxious alien weed. Pakistan Journal of Weed Science Research 11, 1–6.

Javaid, A., Anjum, T., Bajwa, R., 2005. Biological control of *Parthenium* II: Allelopathic effect of *Desmostachya bipinnata* on distribution and early seedling growth of *Parthenium hysterophorus* L. International Journal of Biology and Biotechnology 2, 459–463.

Ko, J., Eom, S.H., Kim, M.J., Yu, C.Y., Lee, Y.S., 2005. Allelopathy of rice husk on barnyardgrass. Journal of Agronomy 4, 288–292.

Macias, F.A., Galindo, J.C.G., Massanet, G.M., 1992. Potential allelopathic activity of several sesquiterpene lactone models. Phytochemistry 31, 1969–1977.

Mattice, J., Lavy, T., Skulman, B., Dilday, R., 1998. Searching for allelochemicals in rice that control ducksalad. In: Odofsdotter, M. (Ed.), Workshop on Allelopathy in Rice. International Rice Research Institute, Makati City, Philippines, pp. 81–98.

Mehboob, N., Saleem, B., Qureshi, M.J., 2000. Allelopathic influence of sunflower on germination and seedling growth of linseed (*Linum usitatissimum*). Pakistan Journal of Biological Sciences 3, 1305–1307.

Netzly, D.H., Butler, I.G., 1986. Root of sorghum exudes hydrophobic droplets containing biologically active compounds. Crop Science 26, 775–778.

Rimando, A.M., Olofsdotter, M., Dayan, F.E., Duke, S.O., 2001. Searching for the rice allelochemicals: an example of bioassay-guided isolation. Agronomy Journal 93, 16–20.

Shafique, S., Bajwa, R., Javaid, A., Shafique, S., 2005. Biological control of *Parthenium* IV: Suppressive ability of aqueous leaf extracts of some allelopathic trees against germination and early seedling growth of *Parthenium hysterophorus* L. Pakistan Journal of Weed Science Research 11, 75–79.

Steel, R.G.D., Torrie, J.H., 1980. Principles and Procedures of Statistics. McGraw Hill Book Co., Inc, New York, USA.

Uremis, I., Arslan, M., Uludag, A., 2005. Allelopathic effects of some *Brassica* species on germination and growth of cutleaf ground cherry (*Physlis angulata* L.). Journal of Biological Sciences 5, 661–665.

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